

AMENDMENTS TO THE CLAIMS

This listing of claims will replace all prior versions and listings of claims in the application:

LISTING OF CLAIMS:

1. (Previously Presented) A reflection type liquid-crystal display device comprising:
a reflection type liquid-crystal display panel including a liquid-crystal cell and a reflector, said liquid-crystal cell having a visual-side substrate, a back-side substrate and a liquid crystal, said visual-side substrate including a transparent substrate, a low-refractive-index transparent layer lower in refractive index than the transparent substrate, and a transparent electrode, said back-side substrate having an electrode, said liquid crystal being held between said visual-side and back-side substrates so that respective electrode sides of said visual-side and back-side substrates are disposed opposite to each other, said reflector being disposed on the back-side substrate side;
at least one illuminator disposed on one of side surfaces of said reflection type liquid-crystal display panel; and
an optical path control layer having a repetitive structure of optical path changing slopes on an outer side of said visual-side substrate and being higher in refractive index than said low-refractive-index transparent layer, each of said optical path changing slopes being inclined at an inclination angle in a range of from 35 to 48 degrees with respect to a reference plane of said visual-side substrate.

2. (Previously Presented) A reflection type liquid-crystal display device according to claim 1, wherein said low-refractive-index transparent layer is disposed between said transparent substrate and said transparent electrode, and there is a difference in refractive index by 0.05 or more between said low-refractive-index transparent layer and said transparent substrate.

3. (Original) A reflection type liquid-crystal display device according to claim 1, wherein at least said visual-side substrate in said liquid-crystal cell is made of an optically isotropic material.

4. (Original) A reflection type liquid-crystal display device according to claim 1, wherein said liquid-crystal display panel further includes one or two polarizers disposed on one of or each of opposite sides of said liquid-crystal cell.

5. (Original) A reflection type liquid-crystal display device according to claim 4, wherein said liquid-crystal display panel further includes at least one layer of phase retarder disposed between said liquid-crystal cell and said polarizer.

6. (Original) A reflection type liquid-crystal display device according to claim 1, wherein: said optical path control layer is constituted by a repetitive structure of prism-like structures; and each of said optical path changing slopes in said optical path control layer faces said illuminator.

7. (Original) A reflection type liquid-crystal display device according to claim 6, wherein each of said prism-like structures in said optical path control layer is constituted by a concave portion shaped substantially like a triangle in section.

8. (Original) A reflection type liquid-crystal display device according to claim 7, wherein each of said prism-like concave portions is constituted by a continuous groove which extends from one end to the other end of said optical path control layer in a ridgeline direction parallel with or inclined to said side surface of said liquid-crystal display panel on which said illuminator is disposed.

9. (Original) A reflection type liquid-crystal display device according to claim 7, wherein said prism-like concave portions are constituted by discontinuous grooves each having a length not smaller than 5 times as large as a depth of said groove.

10. (Original) A reflection type liquid-crystal display device according to claim 9, wherein the length of each of said discontinuous grooves in said prism-like concave portions is approximately parallel to said side surface of said liquid-crystal display panel on which said illuminator is disposed.

11. (Original) A reflection type liquid-crystal display device according to claim 7, wherein said prism-like concave portions are constituted by discontinuous grooves disposed at random.

12. (Previously Presented) A reflection type liquid-crystal display device according to claim 6, wherein each of said prism-like structures in said optical path control layer is constituted by a concave or convex portion shaped, in section, substantially like a triangle or quadrangle having at least two optical path changing slopes facing said illuminator.

13. (Original) A reflection type liquid-crystal display device according to claim 12, wherein said illuminators are disposed on at least two of side surfaces of said liquid-crystal display panel.

14. (Original) A reflection type liquid-crystal display device according to claim 1, wherein said inclination angle of each of said optical path changing slopes in said optical path control layer is in a range of from 38 to 45 degrees.

15. (Original) A reflection type liquid-crystal display device according to claim 1, wherein said optical path control layer is made of a transparent sheet, and is bonded to said liquid-crystal display panel through an adhesive layer having a refractive index higher than that of said low-refractive-index transparent layer.

16. (Previously Presented) A reflection type liquid-crystal display device according to claim 15, wherein said adhesive layer is constituted by a tacky layer.

17. (Previously Presented) A reflection type liquid-crystal display device according to claim 15, wherein each of the refractive index of said optical path control layer and the refractive index of said adhesive layer is higher by 0.05 or more than that of said low-refractive-index transparent layer.

18. (Original) A reflection type liquid-crystal display device according to claim 1, wherein: at least one side surface of said visual-side substrate is protruded outward from that of said back-side substrate; and
each illuminator is disposed on said protruded side surface of said visual-side substrate.

19. (Original) A reflection type liquid-crystal display device according to claim 1, wherein each illuminator is disposed and held on said side surface of said visual-side substrate in such a manner that said illuminator is enclosed by a reflection type light source holder and end portions of said light source holder are bonded to end portions of upper and lower surfaces of said visual-side substrate.

20. (New) A reflection type liquid-crystal display device comprising:
a back-side substrate comprising an electrode and a reflector;
a liquid crystal layer on an upper surface of the back-side substrate;
a visual-side substrate, on an upper surface of the liquid crystal layer, comprising a transparent electrode, a low-refractive-index transparent layer on the transparent electrode, and a

transparent substrate on the low-refractive-index transparent layer, wherein the low-refractive-index transparent layer is lower in refractive index than the transparent substrate;

an illuminator on a side surface of the visual-side substrate; and

an optical path control layer on an upper surface of the visual-side substrate, comprising a repetitive structure of optical path changing slopes on an upper surface thereof, wherein each of the optical path changing slopes is inclined at an angle from 35 to 48 degrees with respect to a reference plane of the visual-side substrate.

21. (New) A reflection type liquid-crystal display device comprising:

a visual-side substrate comprising a transparent layer, a low-refractive-index transparent layer lower in refractive index than the transparent layer, and a transparent electrode layer,

a back-side substrate comprising a back-side electrode,

a liquid crystal layer between said visual-side and back-side substrates,

a reflector adjacent to the back-side substrate;

at least one illuminator on a first side surface of said transparent layer; and

an optical path control layer having a repetitive structure of optical path changing slopes on an outer side of said visual-side substrate and being higher in refractive index than said low-refractive-index transparent layer, each of said optical path changing slopes being inclined at an inclination angle in a range of from 35 to 48 degrees with respect to a reference plane of said visual-side substrate.

22. (New) A reflection type liquid-crystal display device according to claim 21, wherein said low-refractive-index transparent layer is disposed between said transparent layer and said transparent electrode layer, and there is a difference in refractive index by 0.05 or more between said low-refractive-index transparent layer and said transparent layer.

23. (New) A reflection type liquid-crystal display device according to claim 21, wherein at least said transparent substrate is made of an optically isotropic material.

24. (New) A reflection type liquid-crystal display device according to claim 21, further comprising a polarizer on one, of each opposite, side of a combination of said visual side substrate, said liquid crystal layer, and back-side substrate.

25. (New) A reflection type liquid-crystal display device according to claim 24, further comprising at least one phase retarder layer disposed between said polarizer and said combination of said visual side substrate, said liquid crystal layer, and back-side substrate.

26. (New) A reflection type liquid-crystal display device according to claim 21, wherein: the repetitive structure of optical path changing slopes are prism-shaped; and each of said optical path changing slopes in said optical path control layer faces said illuminator.

27. (New) A reflection type liquid-crystal display device according to claim 26, wherein the prism-shaped optical path changing slopes are triangular in section.

28. (New) A reflection type liquid-crystal display device according to claim 27, wherein each of said prism-shaped optical path changing slopes comprise a continuous groove which extends from one lateral end to the other lateral end of said optical path control layer in a ridgeline direction parallel with or inclined to said side surface of said transparent layer on which said illuminator is disposed.

29. (New) A reflection type liquid-crystal display device according to claim 27, wherein said prism-shaped optical path changing slopes comprise discontinuous grooves each having a length not smaller than 5 times as large as a depth of said groove.

30. (New) A reflection type liquid-crystal display device according to claim 29, wherein the length of each of said discontinuous grooves is approximately parallel to said side surface of said transparent layer on which said illuminator is disposed.

31. (New) A reflection type liquid-crystal display device according to claim 27, wherein said prism-shaped optical path changing slopes comprise discontinuous grooves disposed at random.

32. (New) A reflection type liquid-crystal display device according to claim 26, wherein each of said prism-shaped optical path changing slopes comprise a concave or convex portion

shaped, in section, substantially like a triangle or quadrangle having at least two optical path changing slopes facing said illuminator.

33. (New) A reflection type liquid-crystal display device according to claim 32, further comprising at least a second illuminator on at least a second side surface of said transparent layer.

34. (New) A reflection type liquid-crystal display device according to claim 21, wherein said inclination angle of each of said optical path changing slopes in said optical path control layer is in a range of from 38 to 45 degrees.

35. (New) A reflection type liquid-crystal display device according to claim 21, wherein said optical path control layer is made of a transparent sheet, and is bonded to the remaining portions of the liquid-crystal display device through an adhesive layer having a refractive index higher than that of said low-refractive-index transparent layer.

36. (New) A reflection type liquid-crystal display device according to claim 35, wherein said adhesive layer comprises a tacky layer.

37. (New) A reflection type liquid-crystal display device according to claim 35, wherein the refractive index of said optical path control layer and the refractive index of said adhesive layer is higher by 0.05 or more than that of said low-refractive-index transparent layer.

38. (New) A reflection type liquid-crystal display device according to claim 21, wherein:
at least the first side surface of the transparent layer is protruded outward from that of said back-side substrate.

39. (New) A reflection type liquid-crystal display device according to claim 21, further comprising a reflection type light source holder enclosing said illuminator, wherein end portions of said light source holder are bonded to upper and lower surfaces of said transparent layer.

40. (New) A reflection type liquid-crystal display device comprising:
a back-side substrate comprising an electrode and a reflector;
a liquid crystal layer on an upper surface of the back-side substrate;
a visual-side substrate, on an upper surface of the liquid crystal layer, comprising a transparent electrode layer, a low-refractive-index transparent layer on the transparent electrode layer, and a transparent layer on the low-refractive-index transparent layer, wherein the low-refractive-index transparent layer is lower in refractive index than the transparent layer;
an illuminator on a side surface of the transparent layer; and
an optical path control layer on an upper surface of the visual-side substrate, comprising a repetitive structure of optical path changing slopes on an upper surface thereof, wherein each of the optical path changing slopes is inclined at an angle from 35 to 48 degrees with respect to a reference plane of the visual-side substrate.

41. (New) The reflection type liquid-crystal display device of claim 21, wherein the illuminator is positioned on the first side surface of the transparent layer to illuminate light directly into only the transparent layer.

42. (New) The reflection type liquid-crystal display device of claim 21, wherein the illuminator is positioned on the first side surface of the transparent layer, entirely below the optical path control layer.

43. (New) The reflection type liquid-crystal display device of claim 40, wherein the illuminator is positioned on the side surface of the transparent layer to illuminate light directly into only the transparent layer.

44. (New) The reflection type liquid-crystal display device of claim 40, wherein the illuminator is positioned on the side surface of the transparent layer, entirely below the optical path control layer.